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Lake Erie and Ohio River Canal

Adverse Report to the Governor of Pennsylvania, by David Jameson, a Member of the Canal Board

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Lake Erie and Ohio River

Canal Board of Pennsylvania

1916-1917

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FOREWORD

The Acts of Assembly under which the Lake Erie and Ohio River Canal Boards have been appointed, enact "that the Commonwealth of Pennsylvania shall locate, construct, maintain and operate a navigable interstate canal or waterway, etc." This language would seem to imply that the preliminary or investigative stages of the project had been passed. Whatever the view of the Executive and Legislative Departments, inasmuch as the Commonwealth was not expected to furnish the funds required, their endorsement or adoption of the canal project has been assumed by the entire membership of the Board as more or less formal and academic and not in any sense final. No adequate inquiry had been made into the merits of the project and no reports received to justify a conclusive determination. The surveys, topographic, hydrographic and economic, contemplated by the Acts of Assembly, had not at the time of the passage of those Acts been brought to such state of completion as would justify any definite action.

It was proposed that the financial burden involved in the construction of the canal should be assumed largely by the counties expected to be benefitted by it. This fact would justify the State as such in leaving the question of the practicability of the enterprise to those counties and political subdivisions financially interested. However before these counties could be expected to provide the large sums of money needed, they should have before them the results of a careful examination into the merits of the project. This examination I believe the Canal Boards, created by the state, have undertaken to make. They have occupied their time and effort in trying to determine whether or not the canal ought to be built rather than in building it. The predecessors of the present Board employed specialists to make the surveys and estimates contemplated by the Act of Assembly.

The reports and findings of these specialists have, in a large measure, been made to the present Board. A major part of the time of its members has been devoted to a study of these reports. In addition they have at intervals visited the different localities in which the operations of the canal construction would be carried on and from which its water supply would be derived. They have also given some consideration to projects of a similar nature elsewhere in the United States and in Canada.

I am sorry to be unable to agree with the very intelligent gentlemen who constitute the majority of the Canal Board and who join in its report as to many important parts of the problem. I sincerely wish that my conception of my duty in the premises would permit me to record my dissent, and let it go at that; however, the Commonwealth has expended a large sum of money in the making of the surveys and investigations necessarily preliminary to such an undertaking, and the public is entitled not only to the reports of the technical specialties who have been employed, but to the conclusions of the members of the Canal Board, who have been charged with the whole responsibility of the subject up to this time. Those members have made or should have made, a careful study not only of the reports of the different specialists, but of the entire project. Their findings will carry weight in proportion as they conform to the preconceived opinions of individual citizens or as they are verified or invalidated by a study of the problem.

I have given to certain parts of the question a great deal of time and consideration. I have tried to be constructive rather than destructive in my criticisms. I have failed. I began the work with the belief that in the building of this canal rested the future prosperity of the district in which I live and in which nearly all that I possess is invested. After a year and a half of study, I have concluded:

Findings

1. That water in sufficient quantity is not certainly economically available, without violation of the rights of communities entitled to our consideration.

2. That the large amount of money which the building

of the canal would require from them cannot be raised through the several counties, as contemplated in the Act of Assembly.

3. That, even if my first and second conclusions should be invalidated, the canal ought not to be built until there is a greater demand for it upon the part of the public.

4. That its construction ought not to be undertaken until there is more demand for such a canal upon the part of the miners of coal and the manufacturers of iron and steel, upon whose use or non-use of it would altogether depend its commercial success or failure.

5. That the commercial success of the canal, if constructed, and if supplied with water, is extremely doubtful.

6. That such a canal, built by the public, with traffic thereon dependent upon private investment and operation, would not be able to carry traffic, in the limited volume in which it would probably be obtained, as economically or as conveniently for the shippers as the railroads.

7. That the proposed canal, in competition with the 10 to 12 existing lines of railway, between which and the larger makers of iron there is frequent community of control and ownership, would not be able to earn interest upon the moneys that would be invested in it, nor to repay the principal sum.

8. That the canal ought not to be built; and that further expenditures of public money in its promotion should be stopped.

I beg to submit herewith more in detail the reasons for the conclusions at which I have arrived.

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WATER SUPPLY

At the threshold of any discussion of the problems connected with the proposed Lake Erie and Ohio River Canal is that of an unquestionably adequate water supply. 1,127,616 cubic feet of water is required to lock through one boat. I think I may say there is substantial agreement that the minimum annual supply that ought to be thought of is ten billion cubic feet. I believe the engineers and the majority of the Board would say the canal ought not to be built unless there was available an annual supply of fifteen billion feet. Probably no canal ever constructed was confronted with a water supply problem of as great magnitude. The summit level of the canal to which its water supply must be conducted is 31 miles long and is at elevation 900.

THREE STREAMS

It is proposed to draw the large quantity of water needed from three streams, Mahoning River, Shenango River and French Creek, all streams notoriously deficient in water during the summers and falls. At the points at which it is proposed to divert water, these streams have drainage areas as follows: The Mahoning 284 sq. mi., the Shenango 152 sq. mi. and French Creek 682 sq. mi. I have lived for sixty years on these three streams, and my unwillingness to accept fully the conclusions of the Water Supply Engineer as to the quantity of water available to the proposed canal is based somewhat on my personal observation, fortified by inquiry of persons in position to make comparisons between the conditions in the three water sheds, and by a somewhat painstaking study of the bases of the water supply claimed.

MAHONING RIVER

The water supply furnished to the busy cities along the Mahoning has been so deficient much of the time that the enterprising city of Youngstown has found it necessary to expend about one and one-half million dollars upon a conservation or storage scheme. A reservoir has been constructed near Milton, O., with a capacity of about 1,300,000,000 cu. ft. and a surface area at elevation 950, of 2.67 square miles. The feeder for the proposed Lake Erie and Ohio River Canal leaves at elevation 907, passing under the Mahoning River near Leavittsburgh in an inverted syphon, through a tunnel for 300 feet at another place, and with a fall of seven feet in 16.75 miles reaching the proposed canal. This feeder will be 12 feet wide on the bottom and 6 feet deep. Its capacity is calculated to be 140 C. F. S.

It will be noted that water from this source must be taken directly into the proposed canal, and not into any larger storage reservoir. This fact limits the time within which this supply would be available to the season when the large canal would be in operation. The large run off which might be present during the canal's closed season and after the small Milton reservoir was filled, would not be saved. Naturally water needed by the proposed canal from this source would be during the busy summer and fall when the needs of water-power plants, manufacturing plants, cities and riparian owners would be at a maximum. Under the plans of the city of Youngstown, which has built the Mahoning reservoir, the stored water is to be released from time to time and permitted to flow along the natural bed of the river, passing and benefitting all the communities above Youngstown as well as the last named city. The plans of the proposed canal change this materially. They will take the water from the natural bed at a point about four miles above Newton Falls, carrying it by an artificial channel away from Newton Falls and Leavittsburg, with their expensive hydro-electric plants, away from Warren, the fastest growing little city in Ohio, returning it to the river channel at the mouth of Mosquito Creek at Niles.

It seems to me this diversion of water would cause irreparable injury to everybody in any way dependent upon the Mahoning River above the mouth of Mosquito Creek, and would seriously limit manufacturing in all the communities affected. The communities would need the water most at the very time the demands of the canal would call for it.

I do not believe these communities would permit the diversion of any substantial amount of water. Even when the supply was normal in the stream, they would surely object to the depletion of the reservoir because the supply in the reservoir might not be replenished by rains against the dry months when the communities would be depending upon it for water. It seems to me the reasonable demands of the people living along the river should be paramount to those of the proposed canal. I believe they will be able to restrain the taking of water from the Mahoning by the plan proposed by writ of injunction, or that, failing in this, they will be able to collect heavy damages from the Canal Board.

The cost of constructing the Mahoning River supply plant is estimated at $2,253,515. I believe the prospects do not warrant the expenditure.

For the reasons given, I eliminate the Mahoning River from my list of the sources of water supply available to the canal.

SHENANGO RIVER

For a number of years, the Water Supply Commission of Pennsylvania has been at work upon plans by which they hope to increase the flow of the Shenango River during the dry seasons. By the construction of a storage reservoir near the head waters of the stream in Pymatuning Swamp, they have estimated that a flow of 450 cubic feet per second might be maintained at Sharon. This would mean perhaps 600 C. F. S. at New Castle. At nearly all the towns along this stream, the supply of water is much of the time entirely inadequate, although probably in excess of that in the Mahoning basin.

The Lake Erie and Ohio River Canal plans involve the taking over and enlargement of the proposed reservoir in Pymatuning Swamp until it covers an area of 37.4 square miles. The drainage area tributary to the lake would be 152 square miles. In calculating the water from this area, Mr. Isham Randolph, in checking up Mr. Newton, takes the year

1894, as an illustration. He estimates the rainfall for the year at 2.62 feet. This would be 31.44 inches, figures to which I do not except. The Pennsylvania Water Commission Report gives the precipitation for that year in the region above Sharon, as 32.09 inches. Next, Mr. Randolph assumes a run off of 60 per cent. To this figure I take serious exception. I find nothing to justify an expectation of such a run off. The Water Supply Commission of Pennsylvania has made up a table covering 35 years' rainfall and run off in the Shenango water shed, and that Commission makes the ratio of run off 43 per cent. By the method adopted by Mr. Randolph, he gets a run off of 1.57 feet or 18.86 inches. The report of the Pennsylvania Water Supply Commission gives the run off for that year 14.60 inches or 1.21 feet. If this authority is to be relied upon, Mr. Randolph's estimate of run off is 30 per cent. too high.

In calculating the water from the Pymatuning Swamp drainage area, it seems to me Mr. Randolph has made two errors which tend to offset one another. He makes the land area, which would be 152 square miles less the area of the proposed lake, 37.4 square miles, 116.6 square miles, or, he says, 3,731,748,659 square feet. Multiplying this by his precipitation of 1.57 feet would give 5,858,944,394 cubic feet of water. Mr. Randolph gives the result as 5,015,937,485 cubic feet. However, if we are being conservative, we will prefer to take the records and estimates of the Pennsylvania Water Supply Commission, and use a run off of 14.60 inches instead of 18.86 inches, or say 45% instead of 60%. Reduced to feet, we would use instead of 1.57 feet, 1.21 feet. This would make the water from the land area tributary to the Pymatuning Swamp lake, 4,552,733,363 cubic feet instead of either of the larger calculations. Add to this the water falling upon the lake itself or, 2,731,748,659 cubic feet, would give a total of water from this 152 miles of Shenango River drainage area available for the demands of both the Shenango Valley and the canal, of 7,284,482,022 cubic feet. From this Mr. Randolph deducts the evaporation from the reservoir or lake 3,127,956,480 cubic feet, and the requirements of the Shenango Valley to maintain 450 cubic feet per second at Sharon, 6,000,000,000 cubic feet, or a total deduction of 9,127,956,480 cubic feet, leaving a deficit of 1,843,474,450 cubic feet more than the supply.

If this were all there were to it, the hope of getting water from the Shenango for more than the small Shenango branch of the Lake Erie and Ohio River Canal, could be dismissed at once. However the Shenango River has a tributary which enters the main stream a few miles above Sharpsville, called Pymatuning Creek.

PYMATUNING CREEK

This creek has a drainage area of 140 square miles. It is suggested that this creek might be dammed near Orangeville, Ohio, and water stored. This water would be used not for main canal purposes, but to assist in the maintenance of an adequate supply in the Shenango River, and tend to lessen objections to the diversion of water higher up where such water would be available for the Lake Erie and Ohio River Canal.

A number of questions arise regarding the practicability of this part of the enterprise.

It is not expected to bring any new water into the Shenango. Pymatuning Creek has always discharged into the Shenango.

The water which might be accumulated would not in any way compensate Greenville and the riparian owners above the mouth of the Pymatuning Creek for a diversion which took place above them at Turnersville.

I am skeptical as to the merits of the Pymatuning Creek dam and reservoir. The valley is one of those wide flat areas which are referred to by engineers as not adapted to economical storage. In order to close the valley of this small creek, it would be necessary to construct a dam a mile long. The proposed reservoir would cover 9.58 square miles of farm and pasture land. It would extend from Orangeville on the south to beyond Kinsman on the north. Part of the soil is very sandy. The evaporation and seepage would be excessive.

It is much easier to calculate the water needs of a valley at the present time, than to successfully predict what those needs will require forty or fifty years hence, or what the run off will be under changed agricultural conditions.

Mead, in his Water Power Engineering, gives a table of the daily consumption of water by crops, compiled by Mr. W. Tweeddale.

Mr. Tweeddale finds that this table agrees with careful experiments made in France and elsewhere, and calculates from it that from seed time to harvest, cereals will take up 15 inches of water and grass may absorb as much as 37 inches.

This table shows also one of the important reasons why a decrease of stream flow follows the destruction of forests and their replacement by meadows and cultivated fields. It is quite evident also that if the watersheds were covered by grasses or cereals, there would be comparatively little water left for the flow of streams. From this it will be seen that the character of the vegetation on a watershed exerts a considerable influence on the ultimate distribution of the rainfall.

A scarcity of water flowing past any town in either the Mahoning, Shenango or French Creek valleys would certainly restrain the growth and hamper the prosperity of such town. Such injuries to an entire community ought not to be thought of unless the benefits elsewhere are so great as to demand the sacrifice in the name of the good of the greater number. Even then the loser should be compensated in damages, if there is any way in which an entire town can be so compensated.

My opinion regarding the Pymatuning Creek reservoir is, that by the time the Lake Erie and Ohio River Canal could be in active operation, any water which might be stored in this creek would be needed, along with that from the Shenango watershed higher up, to satisfy the demands of the rapidly growing communities of the Shenango Valley, only one of which (New Castle) would be directly benefitted by the construction of the proposed canal. There is already heard from the cities north of New Castle opposition to the diversion of any Shenango River water over into another state to flow down another stream. This opposition might cause legislative intervention to avert a wrong, real or fancied, even after the canal had been built.

It is as certain that the needs of the cities and industries along the banks of these streams will increase with the years as it is that the flow of the streams will decrease, when the lands along their borders are more highly cultivated. As the deficiency of fluid becomes marked, the cry will be "The waters of the Mahoning for the people of the Mahoning, and the waters of the Shenango for the people of the Shenango." This cry will be heard by the law-makers of the two states interested. The needs of the canal will be as they ought to be, secondary to those of the people who have used these waters from time immemorial.

I should not build this canal in the expectation that twenty or thirty years hence it would be getting water in any substantial quantity from either the Shenango or Mahoning Rivers.

This leaves for consideration the last of the three streams from which it has been seriously proposed to obtain water, namely:

FRENCH CREEK

It is to French Creek that we must look for the principal supply of water if the canal is built. The first Board of the Lake Erie and Ohio River Canal, in their report to the Governor, gave the available water as follows:

Source	Cubic Feet
Mahoning River, Pricetown	1,500,000,000
Shenango River, Turnersville	6,000,000,000
Pymatuning Creek, Orangeville	3,500,000,000
French Creek, Bemus Dam	9,000,000,000
Total	20,000,000,000

This estimate makes no deduction for the requirements of the Shenango valley towns, amounting, according to Mr. Randolph, engineer for the construction of the Chicago Drainage Canal, to 9,127,956,480 cubic feet. This last named authority, in estimating the water supply for the Lake Erie and Ohio River Canal for the test year selected by him, ignores the supply from the Mahoning River, as I have done, and he takes 1,843,474,358 cubic feet of water from French Creek to supply the deficit in the Shenango.

The quantity of water to be obtained in any event from the Mahoning is so small, and the prospect of obtaining any at all from the Shenango in dry years is so remote that it will simplify the problem if we drop from consideration these two streams, and recognize the fact that if the proposed canal is to have water, it must get it from French Creek.

Mr. John P. Newton, who was employed to estimate the water supply for the Lake Erie and Ohio River Canal, in answer to my inquiry, gave ten billion cubic feet as the minimum annual supply with which the Board ought to be satisfied. He said, and the estimates of others show, that there should be from ten to fifteen billion feet per annum. In the test year selected by Mr. Randolph, he gets for canal uses 10,448,684,204 cubic feet. Close as this amount is to the minimum, it will be greatly reduced when we apply certain practices recommended by Mr. Randolph himself after his attention had been directed to the results which ought to follow the freezing of the feeder canal from French Creek.

RADICAL DIFFERENCES

The most radical differences between myself and Mr. Newton, whose estimates of water supply were accepted by the majority of the Canal Board, relate to the prospective supply from French Creek. And the main point of divergence relates to the percentage of the rainfall which is discharged in the stream.

The ultimate source of water supply is rainfall. Some of it evaporates, some is absorbed by the land and used by growing vegetation, and some of it runs off in streams. The run off, or discharge in the stream, is what would be available to float boats. Mr. Newton estimates that an acre of land in the French Creek area will produce in the stream 100 per cent. more water than an acre of land in the Mahoning area, and 60 per cent. more than in the Shenango area. I do not think it will do so. I set up my experience in the three valleys and the experience of many others to whom I have talked, against such measurements as Mr. Newton relies upon for his conclusions.

RAINFALL IN FRENCH CREEK

Almost no actual gagings of rainfall in the French Creek area above the point of proposed diversion, have been made except at Sagertown, near the point of proposed diversion. In view of the vital importance of this drainage area to the canal project, it is to be regretted that measurements of precipitation have not been made at widely scattered points throughout the area. The importance of this will be seen by a quotation from a standard work, "Water Power Engineering."—Danial W. Mead, Author. (Page 126, Article 76.)

> "**District Rainfall.**—In determining the average rainfall on a drainage area, an extended series of observations over the entire district considered become essential and conclusions drawn from more limited observations are subject to considerable inaccuracies. Rainfall stations, distributed as uniformly as possible over the drainage area should be selected, and the average result of the observations of these stations should be used as the basis of calculation. Possibly a still more accurate method of considering this subject would be the selection of rainfall observations on each particular branch of the stream considered. The value to be given to each set of observations used should be in proportion to the territory drained by the tributaries."

In order to arrive at an estimate for the region, Mr. Newton assembled the rainfall records of probably all the available gagings over a wide range of country surrounding the French Creek valley. From these he makes an estimate of the rainfall in the French Creek watershed for each year from 1878 to 1912. The mean for the whole period being 42.65 inches. I have taken the same original data, being 655 records of yearly precipitation, have added them together and divided the sum by 655. This gives me an average annual rainfall for all the years covered by the records of 39.5 inches. Mr. Newton's rainfall would therefore be about 8 per cent. more than mine, made from his data, 42.65 inches against 39.5 inches. The average for the Shenango valley for the same time is 39.27 inches.

For the Mahoning valley at Youngstown, Ohio	32.49 inches
For Pittsburgh it was	36.4 inches
For New Castle it was	36.6 inches
For Erie it was	34.6 inches

Mr. Newton's rainfall estimate for French Creek watershed is almost 20 per cent. higher than an average of the places named.

FRENCH CREEK RUN OFF

While Mr. Newton's estimates of the probable rainfall in the French Creek area approach the limit of safety, I feel that his estimates of run off, or discharge, in the Creek go beyond it. My acquaintance with topographical conditions in the three valleys, makes me unwilling to believe that practically 100 per cent. more water runs off of an acre in French Creek Valley than in the Mahoning, or that 60 per cent. more runs off than in the Shenango Valley. The percentage or ratio of run off according to the figures of Mr. Newton are

For French Creek	66%
For the Shenango River, the Water Supply Commission of Pennsylvania makes it for 35 years average	43%
For the Mahoning River at Youngstown	40%

Measured in inches on the drainage area it gives,

For French Creek area	27 ins.
For Shenango River area	16.89 ins.
For Mahoning River area	13.61 ins.

Until this estimate of the run off from the area tributary to French Creek is supported by more and better evidence, I am unwilling to join in a certificate of good character for the water supply of the proposed canal.

In discussing the probable ratio of run off from different areas, so good an authority as the last edition of the Encyclopedia Brittanica, Volume 14, Page 77, under the head of "Catchment Basins of Streams and Rivers," says:

> The following table gives the relation of the average stream discharge to the average rainfall on the catchment basin.—(Tiefenbacher.)

	Ratio of Average Discharge to Average Rainfall	Loss by Evaporation, etc., in per cent. of Total Rainfall
Cultivated Land and Spring Forming Declivities...........	.30 to .33	.67 to .70
Wooded Hilly Slopes............	.35 to .45	.55 to .65
Naked Unfissured Mountains.....	.55 to .60	.40 to .45

In writing about French Creek in his official report, Mr. Newton says, "The stream flows through rolling country well under cultivation." To supply a run off of 66 per cent., according to the authority just quoted, the area should be "naked unfissured mountains." It is very much the same character of country as that which makes up much of the drainage areas of the Shenango and the Mahoning. I question if it produces much, if any, more run off. Daniel W. Mead, in his standard work "Water Power Engineering," gives the rainfall in the three areas as the same, 30 to 40 inches, and he also puts the three streams in the same class as to run off, about 20 inches.

Mr. Newton's estimates of the large run off in French Creek are based largely, if not entirely, upon certain records kept at a bridge in the northeast corner of Mercer County, at a stop on the Erie Railroad called Carlton. I have not enough confidence in those records to make them the basis of an expenditure of many millions of dollars. The figures made there are so extraordinary when compared with other records with which I think it is proper to compare them, as to arouse suspicion as to their accuracy. They began to make records in April, 1908. The average yearly run off for succeeding years was 30.58 inches. In the Shenango Valley, for the same time, the figures show 19.76 inches. Sugar Creek is the next stream east of French Creek. For the year 1912, this stream ran off 15.86 inches. For the same year they claim for French Creek 27.23 inches. For 1913, the records show 22.25 inches and 32 inches. Cussawago Creek is the next west of French Creek. For the years 1912 and 1913, these streams had 20.54 and 21.86 inches and 27.23

and 32 inches respectively, the larger figures being based on the Carlton records of French Creek. The reader should remember that these are inches in depth on the drainage area.

RATING TABLES

If I were to undertake to locate the error which I believe exists in the Carlton records, and upon them it seems to me Mr. Newton's estimate of the water supply of the proposed canal is based, I should place the larger part of it in the rating tables. These tables are made up from measurements made from time to time with a view to the determination of the volume of water passing at different gage heights. The width of the stream is measured, its depth is taken at frequent intervals in order to get the area of a cross section. Then the velocity should be measured at various intervals and depths, because the velocity will be probably twice as great at the middle of the stream at the surface as at the surface near the banks, and perhaps three times as great as at the bottom, depending upon the friction. A study of the Carlton rating tables discloses: First, that the measurements upon which they are largely based were made at flood time. Unfortunately no measurements were made of the stream at the stages when there might be controversy over the right of the canal to divert water, say at gage heights of from 2 to 3½ feet. Second, it appears that the early hydrographers simply took surface measurements of velocity. This was an uncertain method for the ascertainment of a most important factor in the calculation to follow. Rating tables are based upon the theory that at the same gage height, or depth of water, there will always be at the place selected the same width, section and velocity. The Carlton rating tables are based on twenty-five measurements, all but six of them were made either by Mr. F. E. Langenheim in 1909 or by Mr. H. P. Drake in 1910. In checking up one hydrographer by another, I strike some remarkable inconsistencies in the measurements upon which these, to us, vitally important tables are based. I copy from the official records and give below some Carlton measurements made by four different hydrographers:

DISCHARGE MEASUREMENTS OF FRENCH CREEK AT CARLTON, PA.

1908	Width Feet	Area of Section Sq. Ft.	Mean Velocity Ft. per Sec.	Gage Height Feet	Discharge C. F. S.
Mar. 19, K. C. Grant..........	265	1592	4.50	6.74	7170
May 4/09, Langenheim.......	244	1524	4.81	6.60	7338
May 5/10, H. P. Drake.......	265	1423	3.96	6.60	5655
Feby. 25/09, J. D. Stevenson..	263	2112	5.32	8.76	11232
May 2/09, Langenheim.......	255	2791	7.50	11.48	20959
May 3/09, Langenheim.......	255	2228	5.92	9.25	12214
Mar. 1/10, Drake............	265	2208	4.63	9.45	9711

It should be remembered that the farmer or storekeeper who is employed to make the ordinary daily gagings, measures simply the depth of the stream at one point. With this measurement furnished, the rating table is supposed to give the run off or discharge in cubic feet per second (C. F. S.) The rating table is the yard-stick by which the flow of water is measured. If the table is wrong, everything based upon it is questionable. Where, for instance, the gage height is 6.6 feet, there should always be the same width, the same section, the same velocity and the same run off. A study of the above extracts will disclose discrepancies like the following: Hydrographer Langenheim gets a gage height of 6.60 feet, a width of 244 feet, an area of stream section of 1524 square feet and a discharge of 7338 cubic feet per second. Hydrographer Drake, with exactly the same gage height, or 6.60 feet, has a width of 265 feet, or 21 feet more than Langenheim, a section of 1423 square feet, or 101 square feet less than Langenheim, and, what is most important of all, a discharge of 5655 cubic feet per second, or 1683 cubic feet per second less than Langenheim on the same gage height.

Again, Mr. Langenheim, on May 3/09, from a gage height of 9.25′ gets a width of 255′, an area of section of 2228 square feet and a discharge of 13,214 C. F. S. Less than a year later, Mr. Drake, on Mar. 1/10, on a gage height of 9.45 feet, or .2 feet more than Langenheim, gets a width of 265 feet, or 10 feet more than Langenheim, and a discharge of 9711 C. F. S., or 2503 cubic feet per second less than Langenheim. When talking about differences of thousands of cubic feet per second, it is well to remember that there are 86,400 seconds in every day and 31,536,000 in a year. The first difference above would amount to over 145 million cubic feet in 24 hours and to over 52 billion cubic feet in a year. The second difference of 2503 C. F. S. would amount to more than twice as much. Certainly these comparisons and others which can be made, furnish sufficient basis for doubt of the accuracy of the run off records claimed for French Creek at Carlton.

I regard it as unfortunate that gagings were not made on this stream at some place near the point at which it is proposed to divert water to the canal. I regret also that Mr. Newton, the hydrographer employed by the Canal Board, did not measure the stream at Carlton and make an effort to check up and verify the rating table. He did not visit Carlton at all.

ERRORS IN DRAINAGE AREA MEASUREMENTS

A study of Mr. Newton's report on the water supply for the proposed canal, will show that he bases his estimate of not only the run off in French Creek, but his estimate of the quantity that can be diverted at Bemus Dam into the canal feeder, upon the Carlton records. Now Carlton is about seventeen miles, as the stream flows, from Bemus Dam; however, the drainage areas of the two places as given in the report of Mr. Newton as originally filed with the Canal Board, were near enough together to probably cause the hydrographer to conclude other measurements nearer the point of diversion were unnecessary. About a year after the filing of Mr. Newton's report, important errors in the calculation of the drainage areas tributary to Carlton and Bemus Dam were brought to light. The error at Carlton amounted to 73 square miles, that at Bemus Dam to 225 square miles. The Carlton area was brought down from 1070 to 996.8

square miles. The Bemus Dam area was reduced from 907 to 682 square miles. After these corrections, the difference between the area at Carlton and that at Bemus Dam, instead of being negligible, or 10 to 15 per cent., was 36 per cent. Over 300 square miles of the drainage to Carlton did not pass Bemus Dam. It entered the stream between the two places, where there flowed in the outlets from Conneaut Lake, Cussawago Creek and other small streams. Carlton's figures were no longer so easily applied to Bemus Dam. There might be plenty of water at one place, very little at the other. Without a large supply from French Creek, the Lake Erie and Ohio River Canal will be almost as dry as this discussion. I do not hesitate to go on record with the opinion that the millions which it will cost ought not to be expended until this stream has been carefully gaged for a term of years at a station near to the proposed point of diversion, where the question of the supply available to us will not be subject to so many complications. There should also be gagings of rainfall at numerous stations widely distributed over the French Creek area above Bemus Dam.

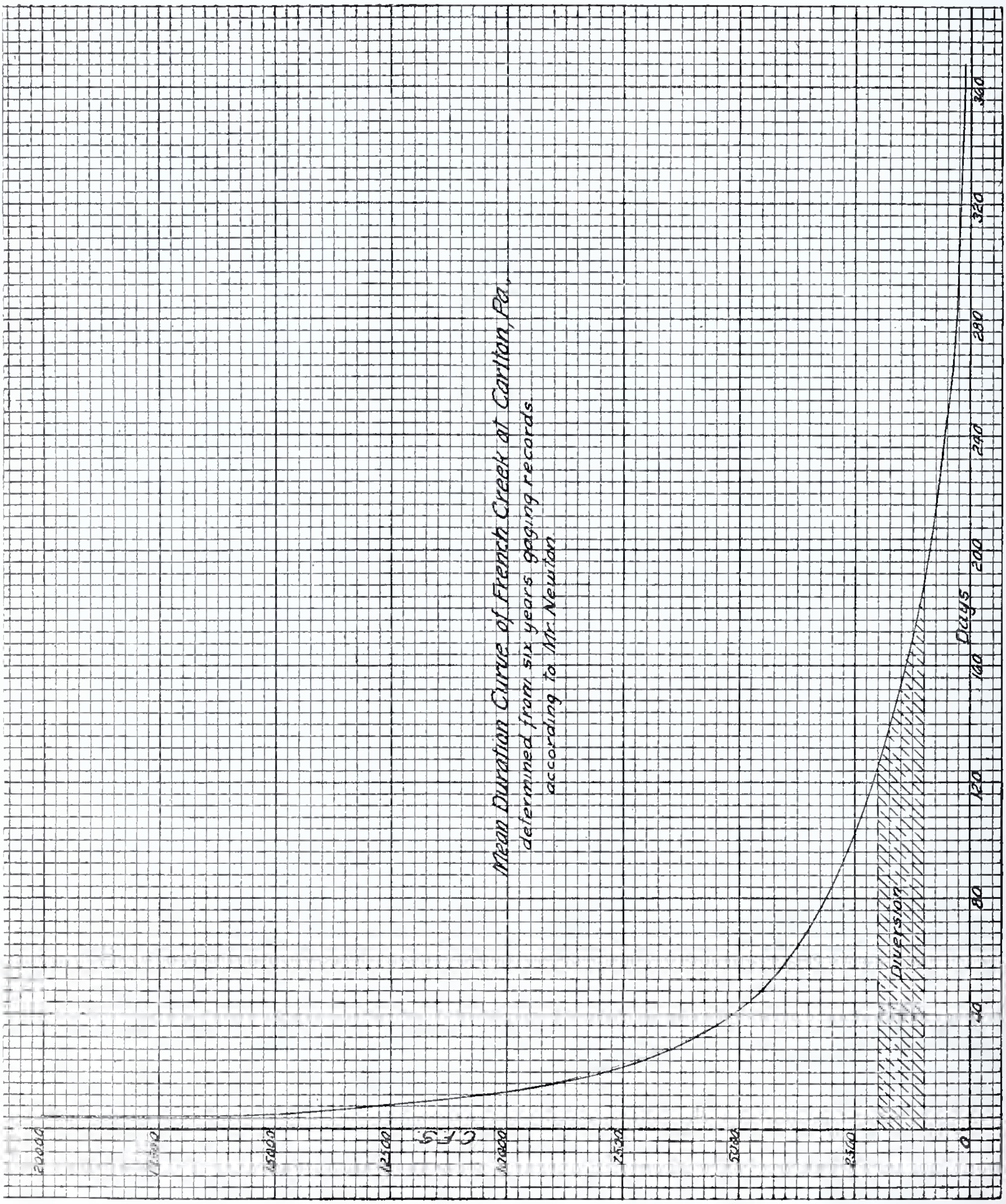
FRENCH CREEK DIVERSION

Water from French Creek is to be diverted by the following method: A dam is to be built two miles above Meadville at the old site of Bemus Dam. From here an open cut feeder will be constructed to a point two miles below Kerrtown, south of Meadville. From this point a pressure tunnel 4,050 feet in length will pass under a hill. The remainder of the feeder, which will be about 20 miles long, will be an open cut with bottom width of 30 feet, surface width of water 68 feet, depth of water 9.5 feet, and carrying capacity calculated to be 1,000 cubic feet per second. This feeder will pass the lower end of Conneaut Lake at an elevation of 11 feet above the lake. This feeder carries the water diverted from French Creek to the Pymatuning Swamp reservoir, etc., has a fall of .63 feet, or, say 8 inches per mile. With this feeder running at its maximum capacity of 1000 C. F. S., 208.33 days would be required to fill the reservoir of nearly 18 billion cubic feet capacity. From this reservoir the water must be carried through another feeder 30.6 miles to the canal. This makes its total journey from French Creek something over 50 miles.

In discussing the water which may be taken from French Creek, Mr. Newton, the specialist upon water supply, says in his report to the Canal Board: "There are two factors tending to limit the available supply from French Creek. **One is the limited size of the feeder from that stream to Pymatuning reservoir which it is practicable to build, and the other is the amount of water which it is permissible to divert, without entailing heavy claims for damages from riparian owners. Investigations along this line show that a feeder of more than 1,000 cubic feet per second capacity could not be economically constructed."** Mr. Newton further concludes that if the flow of the stream is never caused to fall below 1,000 C. F. S. by reason of diversion to the canal, there would be no valid claims for damages. That is, the specialist thinks we cannot economically build a larger feeder than the one planned, and to be safe from heavy claims for damages, we ought not to divert water when it will reduce the flow at Carlton below 1,000 C. F. S. Mr. Newton's original report contains a diagram showing upon how many days in a year there would be at Carlton 1,000 C. F. S. and also upon how many days there would be at the same place 2,000 C. F. S. or more, upon the theory that whenever there were 2,000 C. F. S. at Carlton, the canal feeder could divert 1,000 C. F. S. I do not agree with the conclusions of Mr. Newton, and I shall try to explain the basis of my disagreement.

I have already stated the fact, without undertaking to place the responsibility for it that in the report of Mr. Newton as originally filed, there was an error of 225 square miles in the calculation of the French Creek drainage area tributary to Bemus Dam. When this error was corrected, the difficulty in estimating Bemus Dam diversion on the basis of Carlton run off was greatly increased. We should not reduce the flow at Carlton below 1,000 C. F. S.; but how much can we reduce it at Bemus Dam? At Carlton there is nothing and nobody. Two miles below Bemus Dam is the town of Meadville, with a population of 12 to 13 thousand people, and many industries. It makes no difference how much water there may be at Carlton, but the flow at Meadville is another matter. In my study, I am going to assume that the rights to water at any point are based upon the normal flow of the stream, and that the normal flow would, on the same stream, be determined by the drainage area. The drainage area at Bemus is 64 per cent of that at Carlton. By the criterion established for the Canal Board by Mr. Newton, Bemus Dam and places immediately below it, should have 640 C. F. S., this being 64 per cent. of the amount conceded to Carlton. Water should not be diverted from French Creek for canal uses when it would reduce the flow below Bemus Dam lower than 640 second feet. 640 feet at Bemus is the equivalent of 1,000 feet at Carlton.

If I am right in my premise that it at least is as essential to keep 640 C. F. S. in the stream at Bemus for the important town of Meadville, and others above Carlton, as to keep 1,000 C. F. S. at Carlton where there is nothing but a bridge, some significant consequences follow. The estimated Carlton run off until reduced to terms of Bemus Dam is of little value to us in calculating the quantity of water we may divert, and the diagram drawn by Mr. Newton is misleading. That diagram is reproduced on the following page.


Mean Duration Curve of French Creek at Carlton, Pa.
determined from six years gaging records
according to Mr. Newton
Days
0
40
80
120
160
200
240
280
320
360
Diversion
C.F.S.
20000
17500
15000
12500
10000
7500
5000
2500
0

We must not divert water from the creek for the canal when it would reduce the flow below 640 feet Bemus for the same reason that we must not reduce it below 1,000 feet Carlton, namely, actions for heavy damages upon the part of those who would be deprived of the water. Now if we consult Mr. Newton's diagram, it will be found that he would by it permit us to take the full capacity of our feeder, or 1,000 C. F. S. whenever the gage showed 2,000 C. F. S. at Carlton. It is pertinent to inquire right here how much water there would be then at Bemus Dam. There would be 64 per cent. of 2,000 C. F. S., or 1,280 C. F. S., and when we have taken our 1,000 C. F. S., there would be left only 280 C. F. S. instead of the 640 C. F. S. which ought to be there.

Permitting the point of diversion and the largest town to furnish the criterions as to the quantity we may divert, and getting their requirements or demands by the same rule used by Mr. Newton in deciding what he should allow for Carlton, we should take no water for the canal when doing so would reduce the flow at Bemus Dam below 640 C. F. S. Then for the canal to get 1,000 C. F. S., there must have been in the stream 1,640 C. F. S., 640 for the stream and 1,000 for the canal. But when there are 1,640 C. F. S. at Bemus, there will be more than 2,000 C. F. S. at Carlton. Only 64 per cent. of the Carlton flow comes past Bemus. The balance comes into the creek further down. Dividing the 1,640 C. F. S. at Bemus by 64 and multiplying the result by 100 will give the volume of water at Carlton to be 2560 C. F. S. That is, our canal feeder can take its capacity of 1,000 feet not when there are 2,000 feet at Carlton, but only when there are 2,560 feet at Carlton. Naturally there will be fewer days in which there will be 2,560 feet than in which there will be 2,000 feet. It follows further, that when we make 640 feet Bemus our basis of allowance to the creek, instead of 1,000 feet Carlton, we invalidate the tables, diagrams and estimates of Mr. Newton as to the water available to the canal.

I have made a number of calculations to determine how much difference this change of basis might involve. Bearing in mind, Bemus has always, and at every stage, 64 per cent. as much water as Carlton; conversely, Carlton has 100-64s the water of Bemus. Newton says, when there are 2000′ at Carlton, we can take into our feeder 1000′; I say we can take only 640′. If I am right, his error at Carlton is 560′, or 2560′ less 2000′, and at Bemus the error is 360′, the difference between 1000′ and 640′.

On the next page I give a table modeled after one in Mr. Randolph's report, page 16, showing the water available to our canal feeder in the year 1895, upon the basis of my method, and also on that followed by Mr. Newton and by Mr. Randolph. The latter gets 11,828,954,600′ as the year's supply.

RUN OFF AVAILABLE FOR FEEDER AT BEMUS DAM, IN YEAR 1895

IN CUBIC FEET PER SECOND

Mean Monthly Discharge at Carlton	Mean Monthly Discharge at Bemus Dam	Needs of Creek at Bemus	Feeder Gets According to		Difference
			Jameson	Newton	
January					
1802′	1152	640	512	802	290
February					
1175	752	640	112	175	63
March					
1559	998	640	358	559	201
April					
1505	963	640	323	505	182
May					
1394	892	640	252	394	142
June					
1058	677	640	27	58	31
July					
August					
1049	671	640	31	49	18
September					
1148	734	640	94	148	54
October					
1115	713	640	73	115	42
November					
1970	1260	640	620	970	350
December					
1730	1107	640	467	730	263
			2869	4505	1636

1636′ x 86,400 seconds in a day=141,350,400′ x 30 1-3 days, the average month,=4,287,628,800′.

4,287,628,800′ deducted from 11,828,954,600′=7,541,325,800′, the year's supply.

By Mr. Newton's method there would have been available to the canal nearly 12 billion cubic feet, by my method the volume would have been only 7½ billion cubic feet. This would be only 75 per cent. of the minimum annual requirement for the canal. Disappointing as this may be, there is room for still greater error in these estimates.

It is rather unfortunate that Mr. Randolph selected the year 1895 for his test. This was prior to the taking of any gagings of French Creek, and the run off figures for that year are simply estimates made by Mr. Newton, and based on six subsequent years the gagings in which were accessible to him, namely, 1909, '10, '11, '12, '13 and '14. Mr. Newton has worked out in some way a ratio of run off to rainfall for each month of every year and on his estimate of the rainfall for any past year, by using this peculiar ratio he infers the run off for the year in question. This savers a little too much of guess predicated upon hypothesis to furnish the basis for an expenditure of 100 million dollars. I shall discuss the above ratio further along in my report. The other error which I started to say may be in both Mr. Newton's and my own calculation above, would occur by reason of the fact that **monthly** run off records or estimates are used, instead of **daily** records. Even with daily records or averages, a large factor of error may be present. Our unit of time is a second, and we are discussing thousands of cubic feet per second. It is sufficient to recall that there are 86,400 seconds in a day, to realize how even a small error may multiply. In the month of January in the estimate, there are an average of 1802 C. F. S. at Carlton for the month. This average might have been reached by a flood lasting only a few days, and the stream might have been frozen the balance of the month and no water available for diversion. The maximum capacity of our feeder being 1,000 C. F. S., a flood stage above 2,560 C. F. S. Carlton does not benefit us. There might easily be a monthly average of 1,802 C. F. S. and in the same month be less than ten days on which there would be any water for the feeder to our canal. Perhaps I can illustrate what I mean by taking an actual month in which we can get from the 1912 Report of the Pennsylvania Water Supply Commission the daily gagings of run off at Carlton and the monthly mean run off. Page 217 gives the mean discharge for September as 1,740 C. F. S. Mr. Newton would say, or Mr. Randolph would do so following Mr. Newton's method, we could divert at Bemus 740 C. F. S. every second in the month. 740 C. F. S. multiplied by 2,592,000, the number of seconds in a 30-day month, gives 1,918,080,000 cubic feet of diversion. Following my method above for the year 1895, I reduce the mean discharge for September, 1912, at Carlton, to terms of Bemus, by saying, there will be at Bemus 64 per cent. of 1740 C. F. S., or 1113.6 C. F. S. I deduct 640 C. F. S. for the stream and divert 473 feet, multiplied by 2,592,000 (seconds in September), gives 1,226,016,000 cubic feet for diversion to the canal in that month on the basis of the stream flow at Bemus. However, both of the above calculations are wrong in method in that they assume that a monthly mean discharge of 1740 C. F. S. is equivalent to 1740 C. F. S. for every second in the month. When the actual daily gagings are consulted, it will be found that upon one half of the days in the month absolutely no water could have been diverted, even on the Newton basis of 1,000 C. F. S. Carlton. Instead of diverting an average of 740 feet per second, we could divert only 398 feet, or in cubic feet, instead of 1,918,080,000, we would get only 1,031,616,000. But if, as seems to me the only safe method, we take the flow at Bemus Dam as our basis instead of the flow at Carlton, the water to be diverted will be reduced still further to 877,910,400 cubic feet in September, 1912.

The following month would show a still greater error in the method of figuring from monthly averages. The mean discharge at Carlton for October, 1912, was 2230 C. F. S. Diverting all over 1,000 feet up to the capacity of our feeder, 1,000 feet per second, we would get a maximum flow in the feeder for every second in the 31 days, or 2,678,400,000 cubic feet. While the truth is, the gagings show only 12 days out of 31 on which we could have diverted any water without reducing the balance in the creek at Carlton below 1,000 feet. And, unless I have made some error in my calculation, if we leave in the creek at Bemus 640 feet, instead of getting that month 2,678,400,000 cubic feet, we would have gotten only 840,240,000 cubic feet.

Discrepancies such as I have been pointing out get close to the very sources of the water supply for the proposed canal, and in my mind have raised very substantial doubts regarding the trustworthiness of the fundamental factors upon which and the methods by which Mr. Newton has formed his estimates.

The figures just given are based upon the Carlton records, which records I have already intimated I am unwilling to accept at par. Instead of getting for canal uses in October, 1912, 840 million cubic feet of water, my opinion is that, owing to errors in the rating table for Carlton, the quantity would have been still less even than that reduced figure.

It is almost impossible to think of all the conditions and contingencies which may affect a problem of this kind; however there is one more of importance so great as to demand serious consideration.

THE EFFECTS OF ICE AND FREEZING ON THE WATER SUPPLY

The reports of the Pennsylvania Water Supply Commission for 1912 show that the upper waters of French Creek were frozen so as to prevent gagings from January 6 to March 18, both inclusive, 73 successive days. The same year at Carlton the creek was frozen from January 14 to March 15. No gagings were made. The Cussawago, the next stream west of French Creek above Bemus Dam, was frozen from January 6 to March 19.

Now the important matter is not that for this long period the stream discharge was estimated or guessed at, and this should not be overlooked in passing; but we should inquire into the effect which ice, freezing and thawing will have upon our estimated water supply for the canal and upon the structures which are part of the feeder running 20 miles from Bemus to the Pymatuning Swamp. The question seems not to have occurred to either Mr. Newton or Mr. Randolph until their attention was directed to it by a member of the Board. After thinking it over, Mr. Randolph seemed to fully appreciate the gravity of the ice problem. After going back to his Chicago office he wrote the Board as follows: "Whenever the reservoir is fairly supplied with water at the end of the navigation season, the French Creek feeder should be drained as soon as hard freezing begins, particularly should the siphon be bled, and no water should be admitted until the spring thaw sets in."

What are the dangers to the feeder and siphon from ice and freezing? It will occur to anybody that if thick ice has formed in the feeder, it might for a time cut down the section and reduce the flow. If water flowing over the ice itself freezes, ice to a depth of several feet might form. As thaws occur, one of two things would happen, either (1) with a fall of less than 8 inches per mile, the current would not break up the ice as is done in a natural stream; in which event the ice would remain until melted, obstructing the canal and retarding the flow at the very important time when the spring thaw comes, or (2) the rising water would break up the ice, as it does in a natural stream, causing it to flow with the current along the channel. In this event, other phenomena of ice flows in streams may be looked for. Gorges would form blocking the channel, overflows would follow, earthworks holding the feeder canal would be washed out, the waters and ice poured upon lands at a lower level inundating farms, perhaps villages, endangering life and destroying property, wasting much needed fluid, and putting the feeder out of use at a critical time.

Leaving out of consideration injury to the syphon and other structures, the safest course, if liability for damages which might be enormous is to be avoided, would be to put the feeder out of commission during December, January, February and March, or from the middle of November to the middle of March. Anyone acquainted with the action of streams in that region of heavy freezing, will know that, the question of injury and damages aside, the flow in the feeder would be interfered with most seriously. A large stream discharge in winter months would not avail the canal feeder as would a similar discharge in a summer month. Mr. Newton's estimates are, he told the Board, made without any consideration of the ice and freezing factor. The amount of reduction which its consideration will call for will depend upon our method of computing the interference. If we adopt Mr. Randolph's recommendation, and drain the feeder during, say, the four winter months, it will be easy to calculate the reduction. For illustration, let us take the year 1909. After the presentation to the Board of my criticisms upon the Water Supply Report, and particularly upon that part of this report and that of Mr. Randolph wherein I thought too much importance had been given to Carlton and not enough to Meadville and again wherein monthly averages seemed to have been used instead of daily discharge records, Mr. George M. Lehman, Chief Engineer of the Board, wrote a reply to my criticisms in which he calculated that after allowing 640 C. F. S. for Bemus and Meadville, there would still have been available to our feeder in 1909, 11 billion cubic feet. I agree with his calculation; but take exception to his bases. All such calculations are based on the Carlton records of run off. These I have already said I do not accept. But now let us apply the advice of Mr. Randolph and assume that our feeder was not operating during January, February, March and December of this year. We find that almost half of Mr. Lehman's calculated supply is cut off.

Another illustration can be obtained by applying Mr. Randolph's direction to his own calculation of the supply available to us from French Creek in the year 1895. He gives the supply by months, totaling for the year 11,828,954,600 cubic feet. Of this amount the winter months gave 5,975,255,400 cubic feet, or more than one half of it. There would be left when this was deducted 5,853,699,200 cubic feet.

Do not forget that these figures both of Mr. Lehman and Mr. Randolph are subject to any infirmities incident to the Carlton records.

When undertaking to estimate the diminution in the water supply which snow, ice and freezing would occasion, we should keep in mind Mr. Newton's table of assumed ratios of run off to rainfall. Remembering that the mean annual ratio for streams in this section is 40 to 45, and that Mr. Newton bases his expectations of water on a ratio of 66 in the French Creek area, it is interesting to inquire what his ratios are for these winter months. Below is his table:

Jan.	Feby.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1.20	0.94	1.82	0.797	0.588	0.191	0.094	0.104	0.237	0.35	0.873	0.731

That is, for the four winter months, December, January, February and March, the run off averaged 117 per cent. of the rainfall. For the other eight months of every year it was only 40 per cent. Interference with or suspension of the free flow of the streams and the feeder canal during the winter months becomes a matter of vital importance to the proposed water supply.

RATIOS OF RUN OFF TO RAINFALL

Some further attention should be given to the above table devised by Mr. Newton and purporting to furnish a ratio of run off to rainfall applicable to each month of a year. Mr. Newton says of French Creek, "The stream flows through a rolling country well under cultivation." The run off from such an area should be, according to the authorities, from 35 to 45 per cent. of the rainfall. The balance is largely absorbed by the soil and later taken up by vegetation. A study of Mr. Newton's table will show that he estimates the percentage of run off for January, February and March of each year at 120, 94 and 182 respectively, an average of 132 per cent. This sounds much like a miracle. There is no source of water but rainfall. A heavy run off might occur in a month where it came in the form of melted snow, melted after having accumulated in the preceding month. However water is like money, we cannot spend it and keep it at the same time. The hoards of one month must supply the excesses of another. Looking further, we find that he bases his expectations of water supply for the canal on the assumption that for every six months of every year, beginning with November and ending with April, the average or mean run off would be greater than the precipitation. It seems to me one has only to state such an assumption to show that it is preposterous. Averaging percentages is not always a safe method of reaching conclusions in matters like this. It is possible and probable that heavy snows might pile up in January and February, going out with a March thaw accompanied by very little rainfall. This would give March an enormous ratio of run off. However, January and February would show a corresponding deficit. In this as in other parts of his study, Mr. Newton has used the Carlton records. Only six years of these records were accessible to him. Upon those six years he has calculated averages and based tables which seem to me unwarranted. This table of ratios of run off must be based on those six years, and yet a glance at the records of those years will disclose variations so extreme as to demand records for periods far longer than six years before any approximation towards accuracy or safety can be asserted. For illustration, in the six years, the run off for Januaries, measured in inches on drainage area, varies from 9.255 to 1.498; for the Februaries from 4.917 to .958; for Marches from 11. to 2.652; for Aprils from 6.121 to 1.317. My belief is that tables prepared as this table has been prepared are too precarious for such important uses as this one has been made to serve. The average ratios of run off for six years cannot furnish a trustworthy basis for estimating sixty years.

Mr. Randolph took the year 1895 as his test year. Nearly every fact alleged as to that year is an inference or the result of a calculation from such data and such tables as the one I am discussing. No adequate records of the rainfall are available for different parts of the drainage area. There are no measurements of the run off anywhere for that year. Undoubtedly Mr. Newton made up an estimate of the probable rainfall by taking gagings most of which were made outside of French Creek water shed. Then by means of his table of ratios, he estimated the probable run off at Carlton. Mr. Randolph then took these figures from Mr. Newton, and gave us his deductions. We see how important the table of ratios is in the matter. If they are of doubtful correctness, the entire calculation of our water supply becomes questionable. I am forced to the opinion that the assurances of the adequacy of the water supply made by Mr. Newton and confirmed by Mr. Randolph lack the approximation towards scientific eccuracy which the importance of this branch of our problem demands.

There is plenty of water. The difficulty is in making it economically available. The only objection to bringing water from Lake Erie or the Atlantic Ocean, is that it would not pay. The cost of structures to bring water from French Creek as recommended by Mr. Newton and on estimates made early in 1915, would be seven and one-half million dollars. If made now the estimates would probably be 15 million dollars. This gets us rather close to the limits of economic practicability, without further suggested expenditures, some of which I shall now discuss.

Several plans have been suggested by which the diversion from French Creek might be increased. (1) Mr. Randolph suggests that we increase the section and fall of the feeder. Mr. Newton, who should be much better acquainted with the difficulties, says it cannot be done within reasonable expenditures. (2) Mr. Lehman suggests a dam and storage reservoir at Kimmeytown and above. This would help, but Kimmeytown is a long way from Bemus Dam, and the practicability of materially supplementing the supply by this means was not gone into in any detailed way in the report on available supply of water. The additional water to be obtained in this way will hardly suffice to give the canal more than the minimum quantity which would justify its construction. I believe an abundant water supply should be above suspicion and in no way debatable. For canal uses I distrust the permanency of a supply from water stored by damming the stream as is proposed at Milton on the Mahoning and Kimmeytown on French Creek, creating a reservoir in the stream itself. If water is taken away from a stream at flood time to an independent storage, no question can arise; but if at a dry time, it is proposed to divert water from a stream, riparian owners will surely assert some claim, notwithstanding the fact that most of the water had been conserved by the efforts of the diverters. In such cases the diverters have done only what the people living along the stream might have done to conserve waters which have been theirs from all time, and what some of the people living along the Mahoning actually have done. (3) The third suggestion for increasing the available water is to cut down the allowance of 1000 C. F. S. to Carlton. This I think could be done. However, I have already stated that the claims of Carlton have had small influence on my calculations. When the error of 225 square miles in the drainage tributary to Bemus Dam became known, Carlton lost much of its value as a place from which to reckon. Carlton can do with less than 1000 C. F. S.; but with how much less can Meadville do? I have made the water likely to be at Bemus Dam and Meadville my guides in estimating the diversion. Meadville does not need 640 C. F. S. now, but in the nature of things her needs are likely to increase. In this whole problem, we must keep in mind that we are building for the future. If the business of the canal increases, its fluid needs will increase; if the communities along the streams grow, their demands for water will rapidly increase. On the other hand, as more lands are put under cultivation, or the cultivation on the present areas intensified the flow in the stream will decrease. I can see some additional water from the reduction of the allowance for the creek at Bemus below 640 C. F. S. but not enough.

NEW WATER SUPPLY PLANS

Owing to radical differences of opinion in the Board on the question of the Newton-Randolph Water Supply plans, Mr. F. P. Stearns, of Boston, was employed to go over the matter. His services were secured through the courtesy of The Pennsylvania Water Supply Commission.

COMMENTS ON THE WATER SUPPLY PLAN RECOMMENDED BY MR. FREDERICK P. STEARNS

Mr. Stearns first discusses the above plan prepared by Mr. Newton and approved by Mr. Randolph. I was very much gratified to find that he had reached a conclusion confirming my own. He concludes his comments on the Newton Plan with this paragraph:

"Extended computations based upon the plan above described, show that it would not furnish a sufficient water supply for the canal."

Mr. Stearns' Plan

Mr. Stearns then outlines a plan whereby he thinks an adequate water supply can be obtained. He gives scant consideration to any source of water except French Creek. His chief recommendations can be put under several heads.

1. Enlarge the feeder from French Creek to Pymatuning Reservoir and increase its gradient nearly 57 per cent.
2. Dam both French and Cussewago Creeks, and make the dams high enough to create a reservoir at Bemus Dam; the French Creek dam to be 800′ long instead of 400′.
3. Reduce very greatly the water in the stream below the dam available to Meadville and the lower reaches of French Creek.
4. Construct a reservoir 3 miles below Kimmeytown and about 35 miles above Bemus.

Comments

Mr. Stearns did not visit French Creek nor inspect the proposed route of the feeder canal. His work was done in Boston. His knowledge of actual conditions and difficulties was obtained from others. His principal informant was, undoubtedly, Mr. George M. Lehman, Engineer of the Canal Board. I have a high regard for Mr. Lehman personally and professionally, but this canal has been his hobby for a great many years. The scheme is his scheme. It positively pains him to have it talked about in plain terms. All I intend to say here is that I could wish Mr. Stearns' study had been more independent, and with more personal knowledge regarding the obstacles.

It will very soon be apparent to any student of the French Creek supply, that to have a reservoir at the point of diversion and a larger feeder from it would help immensely. Mr. Lehman has told us for a year that we could not construct a reservoir because of the danger to very valuable property above it, and Mr. Newton, who laid out the feeder, says he made it as large as it can be made without making the cost prohibitive.

Gradient

Mr. Newton, who surveyed the feeder, made the gradient, outside tunnels, etc., .53 feet per mile. Mr. Stearns increases this to .83 feet, giving a velocity, he says, of 2.66 feet per second. This, he says, might cause erosion, and adds, "I do not know enough about the materials available for building the feeder to know whether or not this mean velocity would cause erosion."

He then suggests methods for reducing the velocity by from 2 feet to 2.33 feet per second.

Ice and Freezing

Mr. Newton gave no attention to the effect of ice and freezing in the feeder. Mr. Stearns recognizes it as a very serious problem, calling for special treatment. He proposes to put in the feeder approximately three miles apart, dams to come within 2.5 feet of the maximum water surface. In order that the canal capacity may not be by the dams reduced below 1000 c. f. s., he gives the dams a length of 400 feet. 400′ x 2.5′ equals 1000′. Ice frequently forms in that region more than 20 inches thick. Suppose ice freezes 1.5 feet thick above the dams, leaving a water space 400′ x 1′ or 400 sq. ft.

Again, if the flow in the feeder is from 2 to 2 1-3 feet per second, and the ice is not too thick to break up, may not the dams help to form ice gorges and endanger the banks of the feeder?

Meadville's Requirements

The Stearns computation cuts down the water for Meadville to 100 cubic feet per second during the winter months, and 150 c. f. s. during the remainder of the year, provided there is that much water in the stream. The former Canal

Board, in reporting to the Governor of Pennsylvania their operations for 1914, **Inter alia**, say, "In order to avoid injury to riparian property on French Creek, which might result from a reduction in the low water flow, no diversion of water will be made when the natural flow is less than 1000 cubic feet per second and the water will be taken from the surplus in excess of that amount."

Mr. Newton, endorsed by Mr. Randolph, has said there should be left in the stream 1000 cubic feet per second at Carlton. This would mean about 700 c. f. s. at Meadville. The reason this quantity (1000 c. f. s. Carlton) should be left, was to avoid suits for heavy damages. Mr. Newton has served as an expert in the damage suits which have been brought against the New York Barge Canal. He would be likely to know what courts have decided as to the water which can be claimed by riparian owners damaged by a diversion of a portion of their supply. His experience might make his opinion upon this subject much more trustworthy than that of Mr. Stearns. The latter does not give us any criteria by which we may determine the legal and moral rights of a community in this respect. I read this in a standard legal authority. "In the character of riparian proprietors, persons are entitled to the natural flow of the stream without diminution to their injury, and to them may be applied the observation of Whitlock, J., that a watercourse begins **ex jure naturae**, and having taken a course naturally, it cannot be diverted." That is, cannot be diverted without subjecting the diverter to actions for damages. The diminution must be substantial and the damage actual.

I have little to guide me in arriving at a conclusion as to how much water should be left to Meadville. It is said the town as such would have no standing in a court. However, the Canal Board should not in any high-handed manner take from either Meadville, Pa., or Warren, O., so much of the flow of the stream upon which the town has been built as to limit unduly its future prospects as a location for manufactories requiring a large supply of water, even though the Canal Board or the state cannot be punished for the act. The most reliable guides I can find on the quantity of water needed by a town are obtained from the Shenango. One manufacturing company in New Castle pumps every 24 hours 50,000,000 gallons of water, say 6 million cubic feet, and it will soon need more than that amount. For years the Pennsylvania Water Supply Commission has been working upon a conservation project, which they estimate will give Sharon a minimum of 450 cubic feet per second in the Shenango. I asked the Engineer in charge of the field work if that was all the water Sharon would need, or simply all they could give them. He answered that it was all they could get them, that it would be difficult for anybody to foretell how much they might sometime need. The same difficulty would probably be met with in attempting to predict the future needs of Meadville.

Rainfall and Run Off

Perhaps my most serious difficulty with the estimates of water supply from the French Creek basin, come from the inadequacy of the records of rainfall and stream discharge. The rainfall records do not properly cover the drainage area. There is really only one record in the area worth considering. That was kept by a jeweler at Sagertown, which is near the point of diversion and not central to the drainage basin. Sir Thomas Barclay in the Encyclopedia Brittanica warns against just such methods of relying upon single records of precipitation, and in discussing the variability of gages, gives an actual example where two gages only 70 feet apart varied 20 per cent., and two 560 feet apart varied 30 per cent., depending on location, slope of land, hills, prevailing winds, etc. I believe the quantity of rainfall has been somewhat overestimated, but that the principal error is in the percentage of the rainfall estimated to be discharged in the stream.

Mr. Stearns very properly rejects the preposterous records kept at Carlton and at Kimmeytown as to the five winter months, but accepts them for the seven other months. I am unwilling to be guided by them for any period. For the seven months Mr. Stearns relying upon the Carlton records, would have us agree that an acre in the Shenango valley produces in the stream only 57 per cent. as much water as an acre in the French Creek valley. Or, that an acre in French Creek produces 73 per cent. more than an acre in the Shenango River valley.

My contentions referred to heretofore, regarding the errors apparent in the Rating Table for French Creek at Carlton, have been confirmed and verified by measurements made at this point more recently, and published in the Report of the Water Supply Commission of Pennsylvania for 1915. Evidently having some suspicion of the old measurements, ten new ones were taken. Their effect is to work a very great reduction in the discharge. Here are some illustrations of the changes made, 9.80 ft. of Gage Height instead of indicating a discharge of 14,420 c. f. s., means only 12,180 c. f. s., a difference of 2,240 c. f. s. 3.73 G. H. is changed from a flow of 2,780 c. f. s. to 2400 c. f. s.

Table Showing Errors in Old Measurements at Carlton on Which all Rating Tables Have Been Based, and the New Measurements

Gage Height Ft.	Old Estimated Discharge	New Estimated Discharge	Error in c. f. s.
3.73	2780	2,400	380
9.77	14420	12,180	2240
8.29	10525	8,965	1560
6.05	6460	5,420	1040
5.68	5800	4,785	1015
5.51	5470	4,480	990
4.47	3930	3,098	832

The lack of adequate records of rainfall and the errors in the Carlton measurements of discharge may not wholly invalidate the computations of Mr. Stearns, but they do suggest that the basis for so large an investment should be upon facts more definite and trustworthy.

General Remarks on Water Supply

I have gone into a discussion of the Water Supply so fully (1) because of its vital importance to the project, (2) because in my conclusions I am forced to dissent somewhat from the opinions of specialists employed to consider the question and whose opinions have been accepted by a majority of the Board.

A great many canals have been constructed in the country, which, if not altogether abandoned, failed to meet the expectations of their builders, by reason of the fact, among others, that the quantity of water did not come up to the computations of the engineers. This was the trouble with the old Pennsylvania Canal connecting Lake Erie and the Ohio River. This is the trouble with the canals which Ohio has built between the same lake and the same river. It should be known, and is not to many people, that there are now several canals between these two bodies of water.

The report concurred in by the majority of the Canal Board might lead the reader to infer that the three Engineers employed to plan a water supply were in complete harmony. This is not altogether true. Mr. Stearns says sufficient water cannot be obtained by Mr. Newton's plan. Mr. Newton, who is familiar with the topography of the country and the obstacles to be encountered, says that the plan laid out by Mr. Stearns in his office at Boston, cannot be executed except at a cost that would be prohibitive.

Under the circumstances, I think I am justified in my conclusion that there is not that certitude as yet, regarding an adequate water supply which should characterize the basis for so large an undertaking.

COST OF CANAL AND PROPOSED COUNTY BOND ISSUES

An examination of the reports of Mr. G. F. Stickney, Consulting Engineer, will show his estimates of the probable cost of the different types of canal which have been considered. A good illustration of how changes in thought regarding such waterways compel change of plans and practical reconstruction within periods of say 25 years, is furnished by the fact that the Canal Board has recently determined upon canal dimensions different from any of the many upon which Mr. Stickney made estimates of cost. The depth of the canal proper has been fixed at 12 feet; the locks are to be 400′ x 56′ x 12′. Dimensions used by Mr. Stickney which are nearest to those recommended by the Board are, for a canal with bottom width 180 feet by 12 feet and locks 56′ x 400′ x 12′. Mr. Stickney estimates the cost of the last mentioned dimensions at $89,437,250. See page 12 of letter to the President of the Canal Board, dated Jan. 21, 1916.

Since the above was written, Mr. Stickney has, May 10th, 1917, been asked for an estimate of the cost of the above changed type of canal. He estimates it "on the same basis as the former estimate," as $68,562,000. That is, on the basis of the prices of labor and materials several years ago. Adding to this interest which the counties will have paid out for the average time, will bring the cash outlay by the time the canal proper could be finished to $82,802,327. This cost does not include the lake terminal.

These estimates were made at a time when the prices of all material and the wages of all labor were much lower than now. Most certainly the whole project inclusive of lake terminals and plant terminals, both absolutely essential to successful operation, would cost more than $100,000,000. In my opinion, and I believe in that of other members of the Board, much more.

Mr. Stickney appears to disapprove of the changes made by the Canal Board in the Canal dimensions. Commenting on them in his communication of May 12, 1917, he says:

"While a channel 140′ wide might be navigated by boats of the larger size, the width is not sufficient for economical operation and the cost per ton mile would be increased. The proper width of channel for the larger boats is not less than 180′."

CANAL ZONE

It has been undertaken to lay out a Canal Zone, or region which the canal would specially benefit. It will be found in detail in the letter of Mr. Stickney of Jan. 12, 1916. It comprises eight counties in Pennsylvania, thirteen in Ohio and sixteen in West Virginia. The population and assessed value of property being as follows for the counties in

	Population	Property
Pennsylvania	1,806,043	$1,740,252,099
Ohio	704,116	880,336,740
West Virginia	479,577	522,197,289
	2,989,736	$3,142,786,128

It is not to be expected that all of these thirty-seven counties will contribute to build the canal. When allowance is made for those that are likely to refuse, it would not seem that a contribution of less than three per cent. of the assessed valuations of the remaining counties would furnish sufficient money for the counties' share of the cost of the Canal without the lake terminal. The Federal Government is expected to build the lake terminal at a cost of twelve to fifteen million dollars. I have made inquiries of citizens interested in public affairs and in touch with popular sentiment in a number of counties included in the Canal Zone, and I have received almost no encouragement to the belief that these political subdivisions would be willing to obligate themselves to anything like the extent suggested. In most counties the matter would be submitted to a vote of the people. My inquiries lead me to the opinion that the proposition to bond the county for even two per cent. of the valuation would fail in a large majority of the counties. The assessed valuation of Trumbull County, Ohio, is given as $97,106,580. Under the changed method of making assessments in Ohio, it would now probably exceed 100 million dollars. Ashtabula, Columbiana, Jefferson and Belmont Counties have assessments almost as large. My inquiries lead me to believe the necessary bonds would not be voted in any of these counties. The other counties in Ohio lie along the right bank of the Ohio River. Some of them might vote the bonds but the majority would have less reason to do so than those farther north. Some of them have had canals of their own, and these counties particularly will have to be shown.

My opportunities to make inquiries as to the sentiment likely to develop in West Virginia counties has been confined to four counties. I do not think Wetzell county will vote any bonds. I have little more expectation that Kanawha would do so. In the nature of things West Virginia is farthest away from the proposed canal, and likely for that reason to feel less directly interested. Some of the counties have been heavily bonded for road improvements. They will hesitate to increase their debt for money to be expended in Ohio and Pennsylvania. Moreover those counties, both in Ohio and West Virginia, bordering on the Ohio River, seem to have lost faith in the redeeming qualities of that waterway. They talk as if they would rather pay money to get nine feet of water in the Ohio than twelve feet in the L. E. & O. R. Canal.

In Pennsylvania the large counties outside of Allegheny are Westmoreland $166,841,211, and Washington $123,139,789, in assessed valuations. The rivers touch only a comparatively small part of each county and in each case at the extreme county line. The river districts must needs outvote much of the rest of the county. Washington county has been enterprising enough to make a large issue of bonds for road work.

Some idea of the disposition of the Pennsylvania counties in the Canal Zone towards incurring debts may be gathered from their vote a few years ago on the proposed Constitutional Amendment which would have permitted the state to borrow for road building. In six of the eight counties the proposed amendment was defeated. It carried in Allegheny by only 1100 votes and in Beaver by only 601 votes. Unquestionably the reason for this adverse public sentiment was in the wide-spread distrust of the integrity of the state agencies through which it was expected the money would be expended. The same distrust will in a measure attach to the proposed issue of county bonds for canal construction. The money is to be handled by the state treasury. It is to be expended by a Canal Board to be appointed by the Governor. The humiliating admission must be made that the agencies which have expended large sums of public money in the recent past have at times done so in a manner to destroy public confidence in such agencies. The construction of the State Capitol was a succession of degrading scandals. The State Highway Department, as reorganized by Governor Tener with the best of intentions, got into politics or got politics into it, with the result that the work of the Department was almost universally unsatisfactory to the entire state. The defeat of the proposition to let the Highway Department have the funds it really should have had was nothing short of a rebuke to the management of a state agency. It was a vote of lack of confidence.

The pertinence of these considerations to the present discussion arises when we try to ascertain the trend of public sentiment upon the matter of bond issues for money to be expended by Boards appointed from time to time by the then Governor. For myself I fear it is too soon after the erection of the State Capitol and not far enough away from the reorganization of the State Highway Department to talk about asking a few counties to turn over to this state fifty or one hundred million dollars to be expended by a politically appointed Committee or Board.

To reduce the profits of the railroads and increase the profits of the steel makers would seem to be the desire of the promoters of the canal. This is a bad time to increase the taxes of the people for a purpose so questionable. The railroads claim to be starving, and one steel company says it earned during the first three months of 1917, 113 million dollars. It really looks as if the sympathies of these kindly gentlemen might be misplaced.

TAXES

Taxes will be upon everybody and upon everything for many years to come by reason of the war. The people of the counties are going to think of how many roads, streets and local improvements their contribution to this vast sum needed for the canal would build. When they buy anything made of iron or steel at present prices, the people pay a tax for the benefit of those who manufacture such things. When a steel corporation can make, for months at a time, profits of one and one-quarter million dollars per day, it is idle to talk about mortgaging all these counties in order to widen "the spread" which permits such gains. It should be remembered at all times, that the steel men are not asking the counties to incur these debts. If the U. S. Steel Corporation really needed this canal, they could and would build it out of the profits of a few months. They are doing very well, and they know it. What is equally important, the people at large know it, and there is hardly a possibility that the proposed bonds would be authorized in amount sufficient to even make a start upon the canal.

UNCONTROLLABLE ELEMENTS

There are too many elements of the canal scheme beyond the control of the counties which would largely pay for it. These elements are essential to its success.

1. There is the Lake Terminal, to cost probably $15,000,000. This is expected to be provided by the Federal Government. But will it be forthcoming? All we have is the expression of an opinion by a former Waterways Commission that it ought to be done.

2. Terminal facilities at furnaces which are to handle commodities to or from the canal will cost millions. No attempt was made to obtain assurances that the furnace owners would erect them.

3. Before boats can carry anything like the tonnage estimated, the 9 foot locks in the Ohio River above the Beaver, must be rebuilt by the U. S. Government at a cost of millions.

4. Below the Beaver in the Ohio, even 9 feet of water is not promised for some years. If canal barges designed for a 12-foot canal are to navigate down the Ohio, the work now being done must be done over and the river deepened to 12 feet, a thing not reasonably probable.

5. It seems to me the counties have no assurance that the money they are asked to borrow for the project will ever finish the canal. Perhaps the majority of such undertakings break in two in the middle, even after the expenditure of many millions. Sometimes new engineers call for radical changes in plans. Mr. Stearns has already called for such changes in the water supply plans of Mr. Newton. Very

often the estimates of the engineers fall far short of actual cost.

6. Fleets of boats must be built by those, if any, who can see a satisfactory profit in their operation. Such fleets have about disappeared from most of the rivers and canals of the country, because profits were not satisfactory.

7. To the counties there is no hope of gain in revenue to offset the risk of loss. The counties furnish most of the capital for the construction of the canal; if it fails, the counties lose all; if it prospers, the counties simply get back their capital. The Canal would then belong to the Commonwealth of Pennsylvania.

CANAL FREIGHT RATES

This is a vital question, and one an answer to which it is next to impossible to attain. The answer depends upon so many factors regarding which we have nothing but the guesses of persons poorly qualified to form intelligent opinions. To begin with, here are some important factors:

1. Interest on the cost of the project, including terminals, say five to six million dollars.
2. Sinking Fund allowances for retirement of bonds, say 3 million dollars, or call it depreciation.
3. Annual maintenance, say 1 million dollars.

We already have entirely legitimate annual charges of from 9 to 10 million dollars, or 90 cents to 1 dollar per ton on 10,000,000 tons of freight. The Pittsburgh rate on coal for a long time has been 78 cents. On direct ore, the rate to Pittsburgh has been 88 cents per ton. The rate to the Shenango and Mahoning valleys has been 56 cents. The above canal charge does not include anything for the owner and operator of the boats.

The tonnage which may be carried is the next factor in the ascertainment of freight rates possible. As to this item, nobody can hazard more than a guess. One man's guess is about as good, or as bad, as another's. All guesses are predicated upon conditions which will prevail in from 15 to 25 years from now. Nobody knows what transportation facilities will be afforded them, or what competition exist. No effort was made to obtain estimates of volume from manufacturers and shippers. The above fixed charges should be divided by the number of tons hauled through the canal in order to obtain the amount of such charges per ton of freight. The advocate of the canal will make this tonnage as large as he can; the opponent will make it as small. My guess is, that the canal will not carry an average of 7,500,000 tons per annum for the first ten years, and that, if it does not haul much more than 7,500,000 tons, freight charges on the waterway must be much higher than the rates by railroad.

This item of volume of traffic being a vital factor in all estimates of revenue from the canal, I shall devote some space to certain facts which may bear upon it.

1. The maximum capacity of a canal 12 feet deep, 140 feet bottom width, with single locks 45′ x 340′, is given by Mr. Stickney in one of his communications to the Board as 24,300,000 tons. His calculations as to rates are based on the assumption that the canal will carry 18,300,000 tons, or 75% of its capacity. That all boats will be ideal in size and speed (5 to 8 mi.), that they will haul full loads both ways, notwithstanding the fact that there is no coal to furnish a return haul from Youngstown, New Castle, Midway, Woodlawn and many other places to which iron ore would go. Boats must return to the lake empty, or, go long distances for a cargo.

2. In the largest normal year on record, 1913, the entire tonnage of the Pittsburgh District with the Lakes, was:

Cargo Coal	12,261,334	Gr. Tons
Fuel Coal	836,658	Gr. Tons
Iron Ore	13,411,465	Gr. Tons
Total	26,509,457	Gr. Tons

3. Allegheny County produces about 20% of the pig iron of the country.

4. There are 47 furnaces in Allegheny County. In

1913, they consumed 11,000,000 tons of ore and produced 6,000 tons of iron.

5. Total ore received at Lake Erie ports, in tons:

1913	39,099,647
1914	25,400,655
1915	37,967,468

Shipped from all Lake Erie ports:

1913	30,183,588 tons
1914	20,278,185 tons

6. In recent years, 9,000,000 tons were at lower lake ports at the close of navigation. From this furnaces draw supplies during the winter.

7. Moody's Manual for 1916, says the U. S. Steel Corporation has 127 blast furnaces, north, south, east and west. In 1914, these furnaces made less than ten million tons of pig iron.

8. The U. S. Steel Corporation owns the Bessemer & Lake Erie R. R. from Lake Erie to Pittsburgh. It also owns the Union R. R., which distributes ore, etc., from the Bessemer & Lake Erie R. R. to the different furnaces of the Steel Corporation in the Pittsburgh District.

9. The Jones & Laughlin Steel Company owns the Monongahela Connecting R. R., which distributes ore, etc., to its furnaces. Distributing roads like these get of the rail rates 10 cents per ton, making a very substantial rebate.

10. The tonnage of Canadian canals was in 1913:

Chambly	555,602
St. Peters	71,514
Murray	180,576
Ottawa	265,428
Rideau	171,233
Trent	55,800
St. Andrews	81,295

11. There are between Lake Erie and the iron regions 12 railroads, most of them specially constructed and equipped to carry ore and coal.

12. All furnaces and steel mills make railroad tracks

and switches an integral part of the plant. Raw materials, ore and coal, are brought in upon elevated tracks in hopper cars, and, without manual labor, deposited close to the point where used. Finished product is taken out upon tracks at a lower level.

13. Canals can deliver raw materials only at the lowest level, and usually upon the opposite side of the furnace from where needed. The furnace is between its stock yards and the water in most cases.

14. Business, good will and patronage are frequently matters of reciprocity. Canals consume no iron; the railroads are perhaps the biggest customers of the iron and steel mills. At half the rates charged now by the railroads, how much tonnage would you give the canal? I asked a maker of coarse, heavy product. He answered, "None at all. We get a good business from the railroads; we would get none from you."

14. The National Waterways Commission, Document No. 469, 2d session 62d Congress, made a report on the proposed Lake Erie and Ohio River Canal. It says, the railroads may confidently be expected to make reductions in their rates in an effort to keep traffic from being diverted to the waterway. The report further says, the cost of shipping ore over the Bessemer road is stated to be 2.8 mills per ton mile, or say, 36 cents from the lake to Pittsburgh. The cost of hauling coal on the P. & L. E. R. R., which the canal would parallel for most of its length, according to estimates made by Frank Lyon, attorney for the Inter-State Commerce Commission, is less than 2 mills per ton mile, say 25 cents.

It will be claimed that railroads will not reduce rates to compete with waterways because they cannot raise them again without a hearing before the Inter-State Commerce Commission. However, that is about the only method by which they ever raise rates.

15. Quoting further from the above Senate Report, Document No. 469: "It is the opinion of the commission that the amount of coal which it is expected the proposed canal would carry has been overestimated. The coal deposits in the Monongahela Basin near to the river are becoming

depleted so that it will be more expensive in the future to bring to the river the coal that is to be shipped in barges. This would make it more economical, as well as convenient, to patronize a railroad whose trains reach directly to the mine. Furthermore, some of the coal lands most favorably situated for shipment of their output by water are owned or controlled by persons or corporations affiliated with railroad interests."

Tonnage is as great a factor in the ascertainment of costs on a waterway having a large capital investment as in a mill. The charges applicable to Capital Depreciation, Maintenance, etc., can be approximated, but the volume of traffic is, it would appear, altogether unascertainable 15 years before the fact. Without this unknown and almost unknowable factor, nobody can make an estimate of canal rates at all trustworthy. Mr. Stickney thinks the rate might be $.321. He makes this up of 5% interest on cost of

Canal	$3,683,100
Operation and maintenance	670,000
Fixed charges	$4,353,100

On his estimated tonnage of 18,300,000 tons this would be $.238 per ton.

I would change his figures by saying: 1. His cost of construction is much too low for present times. 2. He does not charge interest on cost of construction of terminals at either end. 3. He does not create a sinking fund to pay bonds nor does he absorb depreciation. 4. In competition with 10 high-class railroads, it is most unreasonable to expect a canal tonnage equal to three-fourths of all that the railroads carried between the Pittsburgh District and the Great Lakes in the biggest before-the-war year on record, to-wit: the year 1913. Revised, I would make the Annual Fxed Charges nearer 10 million dollars, and the tonnage less than 10 million, giving a charge per ton of one dollar. To this I need add only his Cost and Profit on Transportation, $.083, to obtain the prohibitive figures of $1.083 per ton. It is said the cost of transportation by waterway in France was 1 cent per ton mile, or, say $1.30 for the 130 miles of the proposed canal. In Germany, the rate has been given as 5.84 mills per ton mile, or $.76 for 130 miles.

POPULAR DELUSIONS

The people at large labor under numerous misapprehensions regarding the proposed waterway. Perhaps the most prevalent error is in supposing it is to be a ship canal. That lake vessels will navigate its waters as they do the waters of the Sault Ste. Marie canal, connecting Lakes Superior and Huron. This could not be done and has never been contemplated. The clearance provided in the canal as planned, that is, the space between the water and overhead structures such as bridges, is sixteen feet. This space would not admit the passage of boats equipped with upper works to comply with the navigation laws regulating lake commerce.

As matters stand to-day, lake boats cannot navigate the proposed canal, canal boats loaded to capacity cannot navigate the Ohio River nor the Monongahela River.

TIME REQUIRED FOR CONSTRUCTION

Mr. Stickney estimates the time required for the construction of the canal at from 7 to 10 years. For a depth of 12 feet, width of 140 feet, and locks 56′ x 400′ his estimates of time is—years.

Allowing for the contingencies which usually arise in such matters, it is safe to call the period of construction ten years. Even the preliminaries cannot be started until after the war, and some recovery from its heavy taxation and from the demoralization in the labor conditions. Then several years must be spent in getting the bond issues voted and sold, probably five to seven years from now. Some counties will not vote them the first time nor the second. In Ohio three-fifths of the votes must favor the bond issue. Fifteen years, then, would be about the interval between the determination to build and the completion. This is unquestionably one important consideration which adds to the indifference or opposition to the canal. Fifteen years is a long time between the conceiving of a project and the consummation of it. The conditions which it was designed to meet may have so changed as to have cured themselves, or as to require remedies other than those contained in the 15-year-old prescription.

It has been said, the life of a canal is 25 years. By this is meant that most canals have been rebuilt or remodeled every 25 years. If such history repeats itself in the case of the L. E. & O. R. canal, and it cannot be finished for 12 or 15 years, it will have passed middle life before a boat goes through it.

The long time required for construction and the long deference of any benefits to come from it will condemn the project in the minds of many men.

INHERENT DIFFICULTIES. COMPETENT MANAGEMENT. INTERMITTENT SERVICE

The Canal would be, if successful, a great transportation enterprise or plant. Its problems would be unique and peculiar. There would be no experts trained in the management of such a proposition. It is not suggested that the canal should operate boats; however, the fact that it did not do so might add to the difficulties of a management which was trying to obtain business in volume sufficient to absorb one million dollars of annual operating expense, pay interest on the cost amounting to several millions more, and provide for the return of their investment to those who paid for the building of the canal. The management must do this in competition with a large number of railroads managed by business men of the highest capacity and by transportation specialists with years of training at their back. Those who manage the canal will be political appointees. They will have the virtues and the vices usually found in men whose selection comes somewhat as a political favor. If the enterprise should be lucky enough to obtain a manager of exceptional capacity somebody will hire him away by giving him a larger salary than the law will provide for the canal management. A railroad or manufacturing corporation, having an investment of over one hundred million dollars, would be in position to so compensate its managers as to obtain the executive ability required. Those are enterprises handled on principles referred to as "strictly business." The canal would be a business enterprise handled by politicians, with the usual motives and the usual results. Pennsylvania would be doing it. The members of the canal board are officers of the Commonwealth of Pennsylvania. The canal might not be as big a scandal as the state capital, it might not be as universally unsatisfactory to the people of the commonwealth as was the reorganized state highway department under its first Commissioner, but is there enough in the history of the handling of large things by this commonwealth, through the machinery which it creates, to justify a reasonable expectation that the Lake Erie and Ohio River Canal, if constructed, would have the kind of management that would insure its success as a business enterprise? Probably not.

Hibernation

The canal closes up for the winter. The entire investment, and that in boats, lies idle for from four to five months and the employes disperse. Manufacturers are from four twelfths to five twelfths of each year absolutely dependent on the railroads. How many of them will make the large expenditure required to equip their plants to handle freight from the canal? Mr. Morse estimates this expense at $120,000 for each furnace. Intermittent service is unsatisfactory service. Twice a year, in the fall and again in the spring, the manufacturer would require to change his methods. This spells vexation, annoyance and loss of efficiency. You have only to state the proposition to realize the improbability that manufacturers will bother with two methods when one is satisfactory, while the other is non-existent one-third of the time.

There is a lot of human nature in even the transportation business, and nothing pays bigger dividends than fair dealing. The all-the-year customer is sure to get from the railroad better service than the manufacturer who switches to the canal in the summer, and then expects the railroad to have on hand extra equipment ready to take up his work during the winter.

A Canal is Simply a Track

A modern railroad is not simply a right of way and a track. It is not simply a place for somebody else to carry on a transportation business. It is itself the business. A railroad is a right of way, and a track. It is also cars, motive power, highly specialized and trained executive and commercial management. It is engineers, firemen, conductors, brakemen, switchmen, etc., etc. While a canal is simply a right of way and a track. The boats and the real business must be done by private enterprise. Could a railroad succeed being so operated? Can a canal in these United States be successful with its highly competitive business in the hands of Tom, Dick and Harry? Take one of the ten to twelve lines of railroad, which have been constructed with special regard to this traffic in ore and coal, between the iron regions and Lake Erie. Let the state acquire the line, the right of way and the track simply, then invite the public to build, man and operate trains in competition with the highly organized agencies now doing the business. Does anybody think the effort of the state would result in anything but failure? How much better success can be hoped for as to a canal, that is, simply a right a way and a water track?

CANAL FAILURES

If there is a canal of this type in America that has not been a failure, I do not know of it. The L. E. & O. R. Canal would not provide transportation where transportation is lacking. It would not furnish a shorter haul. It would not connect two navigable bodies of water so that the same boats could navigate both without change of bulk. It must simply enter into competition with the best constructed and managed railroads in the world.

Before the great era of railroad construction in this country, some canals performed a very useful function in the transportation economy. When the railroads came, the canals went. It seemed to be, and undoubtedly was, an illustration of the survival of the most commercially fit. As pointed out in the report of the National Waterways Commission, there are certain advantages belonging to the railways which are permanent and inevitable. They have a wider area of distribution; they can be constructed in any direction; they are more readily adaptable to the newly arising and ever-shifting demands of producing areas and of markets. In the handling of freight they have great advantages, because in providing for the receipt and delivery of freight at factories or warehouses, branch lines or switches can be constructed. Railroads can reach all towns and cities alike, whether located on the water or not, while obviously boats or barges can not be used except for the receipt and delivery of freight or passengers from or to localities upon waterways. Railroads have a further advantage in the increasing importance of terminals and facilities necessary for the prompt and economical loading and unloading of freight.

The cost of hauling freight, as compared with the handling or delivery at terminal points, has experienced a great change in the last forty years. The cost of hauling has very materially decreased, while the cost of handling and the expenses connected with terminal facilities, though diminished in many ways, have not decreased accordingly. There is also a readier transfer of traffic from one railroad to another, as compared with the transfer from water to land or land to water. The variation in the level of rivers increases the difficulty of providing an adequate equipment for handling freight on the banks of most of our rivers. The freight carried by rail is more perfectly protected from storm and from the elements, and the railway insures goods carried in its care or handled at its terminals against loss.

FOREIGN CANALS

It is said an argument favorable to the proposed canal can be drawn from the experience of similar water ways in Germany and France. From a government report made some years ago, I learn that the total length of navigable waterways in Germany was 14,344 Kilometers (8,932 miles.) About one-half the total length is not navigable to vessels drawing more than 40 inches. There are already two canals between Lake Erie and the Ohio River with more depth than half the German canals and canalized rivers, one from Cleveland and one from Toledo. The consular report from which I get the above facts, says the government draws no revenue from the canals, while the state railroads showed earnings for the year of $289,308,000.

From the same source, I learn that the French canals are also free of tolls. The navigable length of the principal rivers of France is given as: Loire, 511 miles; Rhone, 340; Seine, 286; Garoune, 247; Dordaogne, 245; Marne, 219; Saone, 201; Lot, 173; Meselle, 168; Allier, 154, and 16 others of from 130 to 50 miles. The chief canals are: Nautes to Brest, 224 miles; Berry, 200; Bourgogne, 150; Marne to Rhine, 134; Loire "lateral," 129; Rhone to Rhine, 118; Nivovaais, 108, and Somme, 97.

It seems to be impossible to ascertain the rates current on these foreign canals. There are no regular rates in most cases. The individual boatman makes the rates and they vary constantly with conditions. Rates are, however, low.

Europe is Not America

Europe is not America, and in nothing do they differ more radically than in their transportation agencies. Even in Germany, the U. S. Consul, writing in time of peace, says, "the inland fleet can exist but not thrive." Our National Waterways Commission, writing about inland navigation in Europe, says: "Frequent reference has been made to the development of waterways in Europe, and sometimes without any adequate comprehenstion of the different conditions existing there. These arise from greater density of population, the earlier development and greater advantage of waterway systems, the existence of a class of boatmen engaged in waterway traffic, who are willing to work with comparatively small gains, and either state ownership of the railways and their management in co-operation with waterways, or complete control and regulation as in Frence, where the railways are compelled to charge 20 per cent. more than the waterways for carrying the same variety of freight. It should not be overlooked that the railway mileage per square mile in the settled portions of the United States is greater than in Europe, and the mileage per 1,000 of population is five times as great in the United States as in Europe, showing that our country is much more adequately furnished with the means for railway transportation."

It has been said the canal across, New York State has failed because it had only 7 feet of water. German canals are claimed to succeed, although more than half of them will accommodate boats drawing only 3 feet and 4 inches. This is certainly some evidence that there are radical differences in the transportation conditions here and abroad. I am disposed to the opinion that one of these differences is in the greater efficiency of our railroads. Discussing English and American railroads, The Literary Digest of July 22, 1916, says: "W. M. Acworth, a careful student of economics and especially of transportation, who has studied these problems for thirty years and on ten occasions has visited this country to inspect transportation systems, is quoted as saying each experience with American roads impressed him with the marvelous results which efficiency had produced with a minimum of expenditure in capital and labor."

AMERICAN CANALS

The body of land lying between the lakes and the Ohio and Mississippi rivers has, from early days, tempted men to ditch it. In order that the State of Ohio might demonstrate a falacy to all parts of the state, several canals were built. They and their history are discussed in a friendly book entitled Ohio Canals. I quote from it: "The canals were never a success in through traffic, especially the Ohio Canal, which with its great length of 308 miles and its immense lockage, 1206′, together with an inadequate water supply on the Licking Summit level, was almost a failure from the start, as a line of through traffic." The Miami and Erie Canal (from

Toledo) was not completed to Lake Erie until 1845, by which time the competition of railroads was beginning to be felt seriously. * * * The Cleveland, Columbus and Cincinnati line was opened in 1851, and soon the canals were left hopelessly behind in the race for traffic. * * * The result was that canal business declined in spite of continual lowering of tolls, until in 1856, the net revenues from the canals fell below the zero point."

I read in the Encyclopedia American under the head "Canals:" "But the great era of American canal-building, and of furious and losing canal speculation, was from 1810 to 1840; its definite close was about 1850, since which year no boat canal has been built in this country, except the Illinois and Mississippi. (This last built canal was a colossal failure.) The entire system in the United States aggregates about 4200 miles, nearly all in the belt from New York south to Virginia and west to Indiana. There are at present about 40 large canals in the United States, of which 14 are in Pennsylvania, 13 in New York, and 5 in Ohio. * * * A history of their fortunes would be of no more importance than of other bygone business ventures"—They might appropriately be referred to as "The Forty Follies."

The Chesapeake & Ohio is a typical canal project for the study of Pennsylvanians. It was designed to run from the Chesapeake and ocean navigation to the Ohio River. It actually does run 184 miles to Cumberland, Md., near Pennsylvania coal fields. Like many similar projects, it was never finished, and never will be. It is 6 feet deep and from 60 to 70 feet wide. It gets its water from 7 dams on the Potomac. The encyclopedia ends its description of this canal by saying, "Its total capitalized outlay had been over $15,000,000, when the bondholders foreclosed in 1890." I presume it is well known that the ownership of this waterway is now in the hands of persons extremely friendly to a neighboring railroad.

The Erie canal opened its 352 miles, from Albany to Buffalo, in 1825, and was a great event in the history of transportation. It was 40 feet wide and 4 feet deep. It was later enlarged to 70 feet at top, 56 at bottom and 7 feet deep. It was fed from Lake Erie, Black River, and several lakes in its course. After the New York Central R. R. paralleled it, the business declined, and for many years after the war seemed doomed to extinction. Tolls were removed and the canal made free in 1883, but this did not arrest the decline. In 1896, it was decided to expend $9,000,000, to deepen the canal to 9 feet, in the hope of reviving the traffic. The money was expended and the work only partially finished. It was next proposed to further deepen the canal to 12 feet, and in 1903, the people by popular vote, authorized the expenditure of $101,000,000 more. The project has not yet been completed, although a further $50,000,000 has been appropriated for terminals and other essentials. If the work is finished in 1918, it will have been 15 years since the money was voted and this simply to enlarge a canal already in existence.

Will the N. Y. State Barge Canal Succeed?

Nobody Knows. Why not wait and find out in the only way in which such things can be found out? If the New York Canal, after an expenditure of over 150 million dollars, does not develop a paying traffic, certainly the L. E. & O. R. Canal ought not to be built. The N. Y. canal is to be 12 feet deep. It is to connect the Great Lakes with the Atlantic Ocean. When all objections to such canals have been named, the greatest is, that they do not pay. There are, or have been, forty in the country, all failures. Will the N. Y. canal make forty-one? There are many who say it will. I would wait and find out. Labor and materials will be cheaper after the war. I would declare a "moratorium" on canal schemes for ten years, and in the interval, watch New York.

Millions Wasted on Rivers

The United States has spent more than half a billion dollars on its rivers. Ex-Senator Burton, than whom there is no higher authority, writes: "It is not too much to say, that fully one-half of the amount expended on rivers has been wasted when tested by the measure of economic results." * * * "A volume might easily be written on the folly of many of our waterway improvements. The most famous river in the United States is the Mississippi. * * * Before the Civil War it carried on its surface a large traffic. * * * And yet today it is almost entirely denuded of commerce, despite the fact that it possesses an excellent channel, and has been improved at a cost of tens of millions of dollars." Probably all the money expended upon this river has been expended with the advice and upon the recommendations of eminent engineers. Still further discussing the Mississippi, Senator Burton says: "In 1881 it was estimated that the cost of obtaining a channel eight feet deep in the section of the river between the mouth of the Ohio and the mouth of the Missouri—or from Cairo to St. Louis—would be $16,397,500. To June 30, 1914, the amount expended on this stretch of the river, almost all of it since the estimate of 1881, was $17,144,999. And yet, after this enormous outlay, it is now officially estimated that it will cost $17,000,000 more to obtain the desired eight-foot channel between St. Louis and Cairo. The cap-sheaf of the absurdity is that this portion of the river has actually had an eight-foot channel for the last ten years.

On this two-hundred-mile stretch of the Mississippi the United States has spent as much as the German government has expended on the Rhine. * * * And yet the traffic of the Mississippi, instead of increasing as a result of these lavish expenditures, is, in fact, steadily decreasing. Last year the freight handled on this section of the river was 281,085 tons, which is about one-half as much as it was eight or ten years ago. * * *

The history of this portion of the Mississippi is typical of conditions over the entire course of the river. The total river trade at St. Louis in 1881 was about fifty times as great as to-day. There is no through commerce worth recording between St. Louis and New Orleans."

There is no longer any river traffic between Pittsburgh and New Orleans. Not a pound of coal has gone down for two years. The coal companies have sold their boats and quit the field. The Federal Government is continuing to expend money in the improvement of the Ohio, and such expenditures would seem to be warranted here if anywhere. That it is warranted is a question not yet proven. To quote Senator Burton again, "We must recognize that just as the wagon gave way to the canal boat, and later to the freight car, so waterway transportation must give way unless it can show its value."

COMPETITION OF LAKE CITIES

Perhaps the most impressive argument in favor of the proposed canal is in the claim that the lake regions, and particularly the Chicago District, are able to make iron at costs lower than those in the Pittsburgh District. I have asked men who have been engaged in making iron in both districts regarding this, and my information is, that the actual costs are about the same in Pittsburgh and in Chicago. The fact that the U. S. Steel Corporation is expending millions to increase its output in both regions would seem to confirm the point. Any advantages are largely in the distribution of the product after it is manufactured. The enormous plant expenditures made and to be made by the U. S. Steel Corporation and others in the Pittsburgh District, at New Castle, Youngstown and elsewhere hereabouts, testify to the merits of this region as a place for making iron.

When the Federal Government took into consideration the comparative advantages which the different parts of the country offered to makers of iron and steel, its armor-making plant was located, not upon the Great Lakes, where no real warship has floated for nearly one hundred years, but in the coal regions and upon a tributary of the Ohio River.

It should be remembered that, if the canal really brings cheaper ore to Pittsburgh, it should take cheaper coal, coke, etc., to the lake ports. The tonnage of ore being much in excess of the available tonnage of coal, in the effort to obtain a return haul, it is probable the predicted reduction on ore might not be so great as on coal, thus tending to further wipe out any advantage to the inland district over the lake districts.

The three items of raw material which are used in the making of iron are, ore, coke and limestone. Our problem is to ascertain the expense incident to the bringing together of these items. Two tons of average ore, one ton of coke and one-half a ton of limestone will produce a ton of iron. There is no difference worth noting in the assembling costs of these materials in the Shenango Valley (New Castle,) the Mahoning Valley (Youngstown) and the Pittsburgh District. I have prepared a statement showing the comparative transportation charges on these materials to New Castle and to Chicago.

Assembling Costs

To New Castle, Lake rate on ore Duluth to Lake Erie port, 60 cents per ton, 2 tons, \$1.20; Rail rate on ore Lake port to stock yard at furnace, 56 cents, two tons, \$1.12; Rail rate on limestone, 32 cents, one-half a ton, 16 cents; rail rate on coke, \$1.20 per ton, one ton, \$1.20; total to New Castle, \$3.68.

To Chicago, lake rate on ore from Duluth, 50 cents, two tons, \$1.00; lake rate on limestone, 25 cents, one-half ton, 12½ cents; rail rate on coke, \$2.50, cost of unloading from boat two tons of ore and ½ ton of limestone, 20 cents, (Stickney Report P. 80). Total to Chicago, \$3.82½. These figures are from practical iron-men, and they show a difference in favor of New Castle over Chicago of 14½ cents per ton.

It is an absolutely safe assertion that nowhere is iron from Lake Superior ores made more cheaply than at some of the modern plants in the Pittsburgh District.

The quantity of iron and steel, finished and partially finished, which goes to markets east is much in excess of that which goes west. In reaching this market and the Atlantic Seaboard the Pittsburgh District has advantages so great as to seem to assure its permanent supremacy in the manufacture of iron and steel products.

ATTITUDE OF LARGE SHIPPERS

Dr. Holdworth's report is filled with valuable statiscal information. It tells us there are 47 blast furnaces in Allegheny county and 52 in the Pittsburgh District. This is far and away the most important district for the proposed canal. It is the only district from which there is much expectation of a return haul after ore has been brought down. It is nearest the coal mines.

How much prospect would the canal have of getting business from the 52 furnaces in the Pittsburgh District? This question appears to furnish a sort of acid test. Without a large volume of business from these 52 furnaces, the failure of the canal is not simply probable, it is certain. We would have the same prospect of getting business from most of those furnaces that any enterprise does of getting patronage from its competitors in the same line of business. That is, none at all. Ninety per cent. of the furnaces belong to people who do not advocate the building of the canal. Seventy per cent., or 37 out of 52, belong to the U. S. Steel Corporation, which already has constructed, and now owns, a line of transportation between the lakes and the Pittsburgh District.

Our problem is not very complicated, and it may as well be faced in candor and in truth. It is not too much to say, that from nearly all the furnaces in the Pittsburgh District we have no hope of patronage. Nobody will blame the U. S. Steel Corporation for not helping to build a competitor for its Bessemer and Lake Erie Railroad, nor for declining to patronize such competitor if it should be built. If the capitalists who control the traffic of The Jones & Laughlin Steel Company and that of the largest shipper of coal, are so friendly to one or more of the existing lines of transportation as to make it probable that they will favor such lines, and there can be little doubt about it, why should the public take on over one hundred million dollars worth of worry? This is not a moral question, it is a business problem. Until the larger shippers want the canal, and want it enough to be willing, in advance, to give some assurance of a paying traffic, public moneys expended upon the proposed undertaking would be simply wasted. There is no principle involved worth the sacrifice. We are not concerned with the motives of these iron and coal companies. We are concerned only with the fact that there is almost no expectation of patronage from them. In business, a pound of fact is worth a ton of theory. A little consideration of the above fact will show one why the practical steel and iron men are almost a unit in regarding the whole canal scheme as vain and chimerical.

The large Steel Companies which appear not to want the canal, have additional control over the coal and iron traffic through their ownership of many of the largest lake boats which carry these commodities.

PUBLIC SENTIMENT

Right or wrong, in a Democracy, Public Sentiment shapes our ends. So far as I have been able to test it, Public Sentiment is not demanding the canal. The iron and coal men simply ignore it. Among practical men one would almost think there existed a "conspiracy of silence." Under the circumstances the average citizen is not heard demanding that canal taxes be added to his already ample list. Furthermore, it does not disturb him when somebody who never made of pound of iron in his life, tells him that manufacturing in the Pittsburgh District will decline, unless the canal is constructed. Partly, perhaps, because in the same breath, the same man will tell him, the railroads will be physically unable to handle the probable increase in the tonnage from the same district. Statements which apparently conflict.

CONCLUSION

If railroad rates are unfair, and if the purpose is by the competition of the canal to control or reduce rates of transportation of ore and coal, the method is too expensive. The public ought to be able to control rates of transportation without the investment of the more than one hundred million (including terminal facilities) which the canal will require. In my opinion, if we are unable to secure the election or the appointment of public officials who will serve the public now; if we are unable to establish tribunals which will award just and fair rates for transportation without the canal, we shall be unable to do so with it. It is a very doubtful and most expensive method of appeal from Inter-state and Intra-state Commerce Commissions.

If the public is at this time competent to successfully manage an experiment in inter-state commerce involving so large an investment, it has, I contend, developed enough business sense to be willing and able to compel public service corporations to deal justly with the public, which creates and maintains them.

On the other hand, if these public service corporations, established by the enterprise of a portion of the citizenship, have dealt justly with the public, then the public ought not to enter into competition with them through a transportation system pledged as this canal is to operate without profit or gain.

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